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Water Transport during Normal Operations of Towboats and Barges in the Illinois River

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16. Abstract (MAXIMUM 200 WORDS)

The primary objective of this study was to determine whether barges and towboats can provide a means for Asian carp to bypass the electrical dispersal barrier in the Chicago Sanitary and Ship Canal (CSSC). Visual inspections of ballast tanks and voids on 132 barges (empty and loaded) and 14 towboats were completed in August 2010. If the water level in an individual tank or void was greater than or equal to 2inches, water depth and temperature of water in the barge tank was determined using a calibrated Yellow Springs Instrument temperature-dissolved oxygen probe. A total of 969 individual ballast tanks and voids were inspected. Only 5 percent of the tanks contained a measurable amount of water. Water depths in barges and towboats ranged between 2 - 117 inches with an average water depth of 11 inches. Water temperature in barge and towboat tanks ranged between 69.2 - 86.7 °F. Dissolved oxygen (DO) in tanks ranged between 0.44 - 7.80 mg/L. Water temperature and DO concentrations in ballasts tanks were within documented ranges of tolerances for Asian carp and other carp species. Although the water quality conditions in the tanks and voids were not optimal and water depth averaged only 11 inches, water quality conditions could support early developmental stages of Asian carp.

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- Illinois Marine Towing (IMT)
- American River Transportation Company (ARTCO)
- Hanson Marine
- Kindra Lake Towing
- American Commercial Lines

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EXECUTIVE SUMMARY

The purpose of this study was to determine whether towboats and barges operating in the Chicago Sanitary and Ship Canal (CSSC) are a possible transport mechanism for Asian carp, an aquatic nuisance species, to cross the United States Army Corps of Engineers (USACE) electric dispersal barrier.

The term Asian carp refers to four species of carp - bighead, silver, grass, and black carp. Common carp were initially brought to the United States from Europe in 1831 and were widely introduced around 1895 as a food fish for a growing European population. Asian carp were also imported but did not arrive until the 1960s (grass and black carp) and 1970s (silver and bighead carp plus a later re-introduction of grass and black carp). In addition to being a food source, they have more recently been used to control submersed aquatic vegetation in and improve water quality of aquaculture ponds as well as control parasite-carrying mollusks in aquaculture ponds. Following escape from ponds or deliberate release, they invaded local rivers and were first documented in the Upper Mississippi River System (UMRS) in 1982. They now generally inhabit these waters, are voracious eaters, and reproduce rapidly. Some species may grow up to four feet in length and weigh up to 100 pounds. In some areas of the Mississippi River, bighead and silver carp are now some of the most abundant species and constitute 90% of the aquatic biomass. Many scientists suggest that these varieties of Asian carp will ultimately reach the Great Lakes and threaten the viability of native fisheries if left unchecked.

USACE constructed an electric barrier within the CSSC to protect Lake Michigan and other Great Lakes from Asian carp that are moving up the Mississippi River and to protect the Mississippi River from fish species advancing down river from Lake Michigan. The CSSC Dispersal Barrier stretches three arrays of electrodes across the canal. The electrodes direct current into the water at a precise voltage, cycle and pulse duration that cause fish to turn back rather than pass through the electrified water.

In June 2010, the Illinois Department of Natural Resources found one live 20-pound Asian carp in Lake Calumet, which lies near the Illinois-Indiana border and is connected to Lake Michigan through the Calumet River. This fish represents the first physical specimen of Asian carp that has been found above the electric barrier system. While the electric barrier is designed to keep adult and juvenile Asian carp from getting into the Great Lakes, little information exists on potential transport mechanisms for other stages of Asian carp, including eggs and larvae.

This study used visual inspections and measured temperature and dissolved oxygen (DO) concentration in tanks and voids of barges and towboats to assess the potential for early developmental stages (eggs and larvae) to survive and potentially be transported above the barrier.

Results of this study indicate that most (95 percent) of the barge and towboat ballast tanks were dry. For those barge and towboats that contained measurable amounts (more than 2 - 3 inches) of water in an individual tank, water temperatures and DO concentrations were within published tolerances for either Asian carp or other carp species.

Results from this study suggest that water quality conditions in barge and towboat ballast tanks during one season (summer) would be able to sustain juvenile to adult Asian carp. Earlier life stages (i.e., eggs, larvae)

are less tolerant of high temperature or low DO, thus it is not known if or how long Asian carp eggs or larvae could survive in ballast tanks. If these life stages are able to survive in the ballast tanks, it is possible that they could be discharged through leaks or ballast tank exchange above the barrier. Further investigation into survival of early life stages in tanks is needed.

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LIST OF ACRONYMS

ARTCO	American River Transportation Company
CSSC	Chicago Shipping and Sanitary Canal
DNA	Deoxyribonucleic Acid
DO	Dissolved oxygen
e-DNA	Environmental DNA
EPA	Environmental Protection Agency
GLRI	Great Lakes Restoration Initiative
IDNR	Illinois Department of Natural Resources
IMT	Illinois Marine Towing
KLT	Kindra Lake Towing
NIS	Non-indigenous species
RDC	Research & Development Center
ULT	Upper lethal temperature
UMRS	Upper Mississippi River System
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
YSI	Yellow Springs Instrument

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1 INTRODUCTION

The United States Coast Guard (USCG) is tasked by the National Aquatic Nuisance Prevention and Control Act (1990) and National Invasive Species Act (1996) with eliminating as much as possible the introduction of non-indigenous species (NIS) via ballast water. Under the Great Lakes Restoration Initiative (GLRI) Act, the Coast Guard has been funded by the U.S. Environmental Protection Agency (EPA) to investigate the potential for towboats and barges to transport Asian carp and other species within the Chicago Shipping and Sanitary Canal (CSSC) and across the electrical dispersal barrier constructed by the U. S. Army Corps of Engineers (USACE) as a preventive measure to keep fish from migrating into and out of the Great Lakes.

Four species of Asian carp now flourish in waterways of the contiguous United States. These include grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molotrix*), bighead carp (*H. nobilis*) and black carp (*Mylopharyngodon piceus*). These species were imported to control submersed aquatic vegetation, control snails that harbor a fish parasite, and improve water quality of aquaculture ponds. They have now invaded river systems following escape from ponds or deliberate introductions into the wild. Big head and silver carp are filter feeders that grow and reproduce quickly and effectively out-compete native species of fish.

There is significant concern that if Asian carp successfully cross the dispersal barrier, they may establish a reproducing population in Lake Michigan and spread to the remaining Great Lakes. This would threaten the Great Lakes ecosystem as well as the multibillion dollar recreational and sportfishing industries.

Both bighead carp and silver carp are established in the Illinois River downstream of the CSSC. On November 20, 2009, USACE announced that a few samples of environmental Deoxyribonucleic Acid (e-DNA) from Asian carp had been found above the electric dispersal barrier in the CSSC (USACE, 2009). On December 2, 2009 the CSSC was closed to allow for scheduled maintenance for the electric dispersal barrier. In order to prevent the upstream migration of Asian carp while the dispersal barrier was offline, the Illinois Department of Natural Resources (IDNR) and other Federal, State, and Canadian authorities began dispersing rotenone, a fish poison, to a six mile stretch of the river immediately north of the Lockport lock and dam. Although no Asian carp were found in that area of the CSSC during the two months of commercial and electrofishing before the December 2009 discovery, the massive fish kill did result in the finding of a single Asian carp (IDNR, 2009).

There is a continuing concern that Asian carp eggs, larvae and fry may be taken up in ballast water or leakage water of towboats and barges downstream of the electric barriers and that these vessels may be transport vectors for these species allowing them to cross the USACE electric dispersal barrier. If they are released during deballasting upstream of the dispersal barrier, Asian carp could enter the Great Lakes and potentially become established. This Towboat/Barge Sampling Study assesses the scope of the potential threat by surveying barges and towboats to determine the percentage of tanks carrying water and the number of vessels transiting the CSSC.

2 METHODS

Visual inspections of barge and towboat ballast tanks and voids (hereafter called ballast tanks) were conducted along the CSSC in the vicinity of Lemont, IL (Figure 1) between 18 and 26 August 2010. Barge companies in this area were contacted for access to available barges and towboats. In addition to barges in the Lemont, Channahon, and Romeoville areas, barges owned and operated by Kindra Lake Towing (KLT) in Chicago were also inspected. KLT occasionally moves barges/towboats through the Lemont area. Table 1 indicates the locations of vessels inspected during this study. A brief description of towboat and barge designs and water handling operations is provided in Appendix C.

Figure 1. Barge and towboat ballast tank sampling locations (red dots) along CSSC (red line), August 2010.

Table 1. Vessel company and location of barge and towboat sampling, August 2010.

Vessel Company	Location
American River Transportation Company (ARTCO)	ARTCO Shipyard (Lemont)
Illinois Marine Towing (IMT)	Channahon, IL
IMT	Heritage Storage Yard
IMT	IMT (Channahon)
IMT	Lemont, IL
American Commercial Lines	Lemont, IL
ARTCO	Lemont, IL
ARTCO	Morris, IL
ARTCO	Ottawa, IL
ARTCO	Power Plant (Romeoville, IL)
Hanson Marine	Romeoville, IL
Hanson Marine	Romeoville/Loading area
ARTCO	Seneca, IL
Kindra Lake Towing	South Chicago, IL
Kindra Lake Towing	Walsh Slip (Chicago, IL)

Ballast tanks from barges, either rafted along the river bank or at the operator's shipyards, were visually inspected for the presence of condensation and/or measureable amounts of water. Three types of barges were sampled: tank barges, deck barges, and hopper barges. The number of ballast tanks per barge ranged from 6 to 18, depending on the type of barge. Tank barges had separate port and starboard wing tanks with a bow and stern tank, while deck barges had separate port and starboard tanks separated by a bulkhead at the keel creating separate port/starboard ballast tanks. Several of the deck barges were found to have port, center, and starboard tanks per section resulting in a high number of ballast tanks present. Ballast tanks ran side to side on hopper barges.

Data for all barges and towboats inspected was recorded on data sheets in the field. Data included: barge type, number of ballast tanks, location of ballast tank inspected, hatch type and condition, condensation presence, and whether hatch was sealed. Water depth was determined using a weighted measuring tape that was lowered into the ballast tank. Depth was determined from deck level by measuring the point where the weight was observed hitting the surface of the water to the point the weight reached bottom of the tank. If the water level in an individual ballast tank was measurable (defined as greater than or equal to 2 inches, as determined with a tape measure), a Yellow Springs Instrument (YSI) Model 550A Temperature-Dissolved Oxygen probe was then used to record temperature and dissolved oxygen (DO).

Information regarding the number of barges and towboats passing through the CSSC annually (2007 data) was also obtained from the USACE and is presented below in Section 3.4. This information does not necessarily reflect the actual number of vessels transiting over the dispersal barrier as some local vessels cross the barrier but do not transit the full CSSC.

3 RESULTS

3.1 Water Depth

3.1.1 Barges

Between August 16 and 25, 2010 a total of 969 individual ballast tanks were inspected on 132 barges and 14 towboats. Data obtained during the survey is provided as a table in Appendix A. The photographs in APPENDIX B show several barge types, hatch arrangements, and clearances under bridges. Barges sampled included 19 deck barges, 99 hopper barges, and 14 tank barges. Of the 969 ballast tanks inspected, 50 ballast tanks (5.2 percent), all of which were on barges, had measurable levels of water. Water depths in these ballast tanks ranged from a low of 2 inches to a high of 117 inches (Figure 2). Water depth in deck barges ranged between 4.5 – 24 inches, while hopper barges ranged between 2 – 117 inches (Figure 2). No measurable water was found on tank barges.

For all barges with measurable water in their ballast tanks, overall average water depth was just over 11.0 inches. When three hopper barge tanks with depths of 42, 76, and 117 inches are excluded, water depth averaged 7.2 inches. No information was available to determine why these three tanks contained more water than the remaining 47 tanks with measurable water.

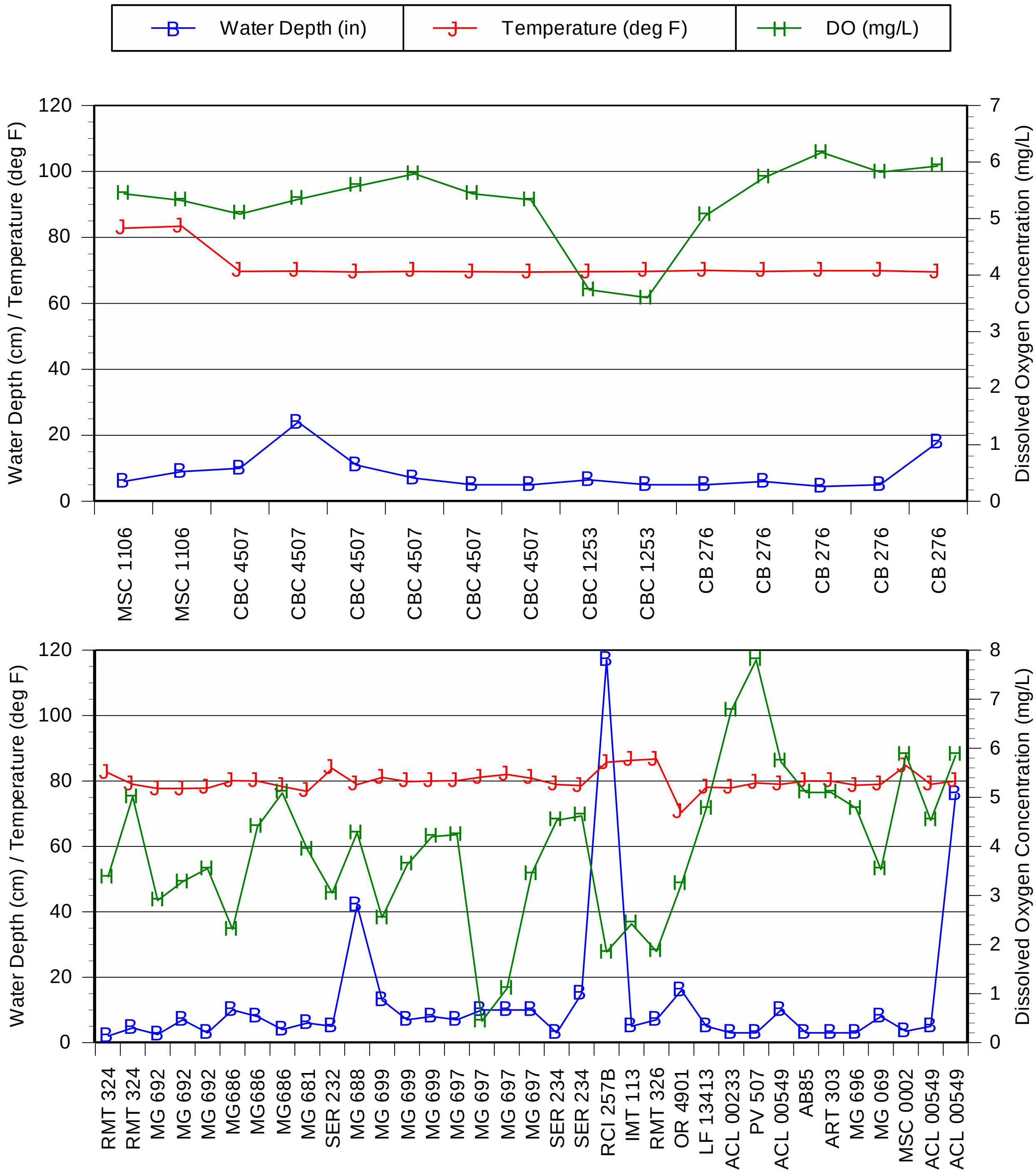

Figure 2. Water depth (inches), water temperature (°F), and DO concentration (mg/L) for deck barge (top) and hopper barge (bottom) ballast tanks sampled in August 2010.

3.1.2 Towboats

Of the 14 towboats inspected in August 2010, only four had measurable amounts of water in their ballast tanks. Water depths for towboats ranged from a low of 18 inches to a high of 72 inches (Figure 3). Average water depth for towboats was 50.5 inches. No information regarding the ballasting of the towboats was available. Towboat operators indicated that ballasting is not routinely conducted.

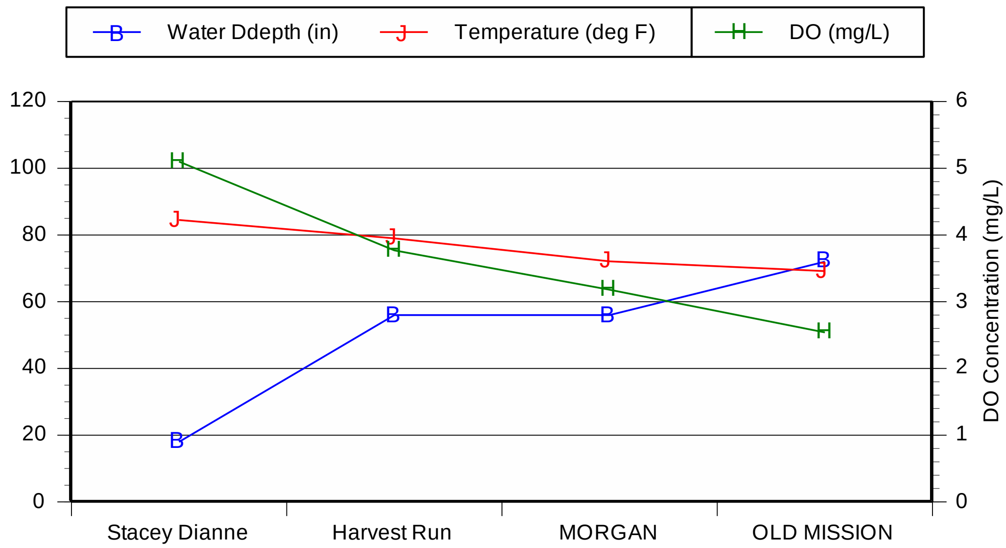

Figure 3. Water depth (inches), water temperature (°F), and DO concentration (mg/L) for towboat ballast tanks sampled in August 2010.

3.2 Water Temperature

3.2.1 Barges

Water temperature (°F) was recorded for the 50 barge ballast tanks that contained measurable amounts of water and ranged between 69.5 - 86.7 °F. Water temperature was relatively consistent in most ballast tanks. For deck barges, water temperature ranged between 69.5 - 83.4 °F, with an average of 71.5 °F (Figure 2). Water temperatures for hopper barges ranged between 70.4 - 86.7 °F (Figure 2). Average water temperature in hopper barges was 80.0 °F. For all hopper and tank barges combined, average water temperature was 77.4 °F. As mentioned above, there was no measurable water in tank barges.

3.2.2 Towboats

Water temperature in towboat ballast tanks ranged between 69.2 - 84.5 °F (Figure 3) with higher temperatures found in those tanks with less water. Similarly, the ballast tank with the most water (72 inches) had the lowest temperature. Average water temperature in towboat ballast tanks was 76.2 °F.

3.2.3 Ambient Conditions

Ambient water temperature was measured at approximately 1 meter depth alongside the barges twice during the survey. Water temperature at the IMT Channahon facility on August 17 was 86.3 °F. Water temperature of 70.0 °F was recorded at the Kindra Lake Towing facility near Chicago on August 19. In general, one can expect higher water temperatures in summer in the Lemont area (average = 80 °F) than in those areas closer to Lake Michigan (average = 71.5 °F).

3.3 Dissolved Oxygen (DO)

3.3.1 Barges

DO concentrations in the water of the 50 ballast tanks ranged between 0.44 - 7.80 mg/L and were highly variable. For deck barges, DO ranged between 3.60 - 6.17 mg/L, with an average of 5.29 mg/L (Figure 2). For hopper barges DO concentrations ranged between 0.44 - 7.80 mg/L. Average DO in hopper barges was 3.98 mg/L. No apparent trends in DO concentration were observed between barges with more water compared to those with less water in their ballast tanks. Tank barges did not contain sufficient water to measure DO. This is not unexpected since tank barges are inspected by Coast Guard after collisions, elisions, etc and, if leaks are found, are removed from service until repairs are made.

3.3.2 Towboats

DO concentrations in ballast water from towboats ranged from 2.54 - 5.10 mg/L (Figure 2). Average DO in towboats was 3.65 mg/L.

3.3.3 Ambient Conditions

As was done with water temperature, ambient DO was also measured twice during the survey at approximately 1 meter depth alongside the barge. DO at the IMT Channahon facility on August 17 was 2.76 mg/L, while DO at the Kindra Lake Towing facility near Chicago on August 19 was 8.46 mg/L. This large difference could potentially be an artifact of sampling (morning vice afternoon or proximity to Lake Michigan) since the KLT sample was taken in the morning and the IMT sample was recorded in the afternoon.

3.4 Vessel Traffic

USACE Navigation Center (http://www.ndc.iwr.usace.army.mil/) keeps records on traffic through the CSSC but does not keep records of traffic over the electric fish barriers, Annual vessel traffic passing through the CSSC was obtained from USACE for 2007 and is presented in Figure 4. Traffic totaled 5,792 vessels including 2,246 liquid hazardous cargo barges, 2,650 commercial vessels, and 896 recreational vessels. A variety of barge types cross the electric barrier each year, including hopper, tank, and deck barges similar to those inspected in this study. The number of vessels actually crossing the electric fish barriers is difficult

identify. For example, a tow could go upbound through Lockport Lock, deliver to a site south of the barrier, and then head downbound through the lock again and be counted as passing through the CSSC but would not have crossed the barrier. Likewise local traffic could begin below the barrier, transit the barrier, deliver goods in Chicago, and return back across the barrier and not be counted as having passed through the CSSC,

Figure 4. Annual vessel traffic across the electric fish barrier in 2007 (Source USACE/OMNI).

4 DISCUSSION/CONCLUSIONS

It is widely accepted that water temperature, flow conditions, food, and predation are important factors influencing larval survival and growth. Little information exists on water quality tolerances such as temperature and DO for Asian carp especially the early stages of development such as eggs and larvae. Most of the existing literature focuses on common carp (*Cyprinus carpio L)* and grass carp (*Ctenopharyngodon idella*), which is also an Asian carp species.

Opuszynski et al. (1989) found the upper lethal temperature (ULT) for silver carp was 43.5 - 46.5 °C (110-116 °F) and also found no significant differences in survival of fish reared at lower and higher temperatures when proper food was used. Golovanov and Smirnov (2007) used the chronic lethal impact method with a water heating rate of 1 °C/day or 0.04 °C/h (1.8 °F/day or 0.07 °F/hr) to determine ULT for common carp. At 1 °C/day, (1.8 °F/day) fish successfully acclimated to temperature increases.

Silver carp are also quite tolerant to low water temperatures and have been reported to feed at water temperatures of 10 - 19°C (50-66 °F) in Israel (Leventer 1979, cited in Wrigley et al. 1988). When the water temperature dropped below 15°C (59 °F), the appetite of silver carp was reduced, and below 8-10°C (46-50 °F), feeding almost ceased (FAO 1980; Tripathi 1989). At water temperatures below 18°C (64 °F) or higher than 31°C (88 °F), rates of ovulation and hatching of silver carp have been reported to be low with high rates of abnormal embryonic development (FAO 1980).

Grass carp tolerate a wide range of water temperatures from 0 - 33 °C (32 - 91 °F), with temperatures greater than 38 °C (100 °F) being lethal for adults (Federenko and Fraser, 1978). ULT for grass carp fry ranges from 33 - 41 °C (91 - 106 °F), and for yearlings the range is 35 - 36 °C (95-97 °F), depending on season (Chilton and Muoneke, 1992). Grass carp also appear to tolerate moderately rapid changes in temperature. Shireman and Smith (1983) found fingerlings (5 - 7 cm or 2 - 3 inches) could tolerate temperature increases from 4 - 22 °C (39 - 72 °F) over a relatively short amount of time (~2 - 3 hours).

Bighead carp can tolerate extremes in water temperature, from cold temperate to tropical (Kolar, et al. 2007). In their native range in China, bighead carp can spawn at temperatures as low as 18°C (64 °F) in the Han River (Chunsheng, et al. 1980). Negonovskaya (1980) reported bighead carp fingerlings feeding activity continued at 10 °C (50 °F) in lakes in Russia's Pskov Region, but most active feeding activity occurs at 20 - 22 °C (68 - 72 °F). Experiments with thermal preferences conducted in Texas (Bettoli, et al. 1985) indicated that young bighead carp (56 - 73 mm) acclimated to temperatures at 23.0 ºC (73 °F), selected a mean temperature of 25.4 ºC (78 °F), and had their critical thermal maximum at 38.8 ºC (102 °F). Although little information exists on lower water temperature lethal limits for this species, the presence of bighead carp in rivers and reservoirs in the Manchurian Plain that remain frozen 4 to 6 months out of the year suggests that the species is quite cold tolerant.

The vast majority of ballast tanks sampled (919 of 969; 95 percent) were dry; water in the ballast tanks sampled in the current study had little variability in temperature and ranged between approximately 70 - 87 °F (21 - 30 °C) which was similar to the two ambient river temperatures measured. Comparison of temperature ranges in the barge ballast tanks with values found in the literature suggests that Asian carp larvae could potentially tolerate the range of temperatures found in the tanks.

Information on carp (adult, juvenile, or larvae) tolerances to DO concentrations is extremely limited. Cudmore and Mandrak (2004) found DO levels below 3 mg/L can cause stress in grass carp. Shireman and Smith (1983) reported that the same species could tolerate DO concentrations as low as 0.2 mg/L and fingerlings survived in DO levels between 0.41 - 28 mg/L. Other studies have also found that young grass carp are more susceptible to low DO concentrations than older fishes and that vulnerability varies with season (Chilton and Muoneke, 1992) with less tolerance for lower DO concentrations in colder (winter) water compared to more tolerance for lower DO concentrations in summer, when the waters are warmer (Versar, Inc., 1999).

DO concentrations in barge and towboat ballast tanks measured in this study ranged between 0.44 - 7.80 mg/L. This is well within the range of tolerances for other carp species and is likely within the range for bighead and silver carp. This suggests that water quality conditions with ballast tanks, although not optimal, could support early life stages of Asian carp.

Of the 969 tanks and voids inspected during August 2010, 50 barge tanks (5.2 percent) had measurable levels of water. In April 2010, a visual ballast tank inspection was conducted (no water quality sampling) by Asian carp workgroup members as part of the planning for this study. They found that of the 127 ballast tanks inspected, only 4 tanks (3.1 percent) had greater than approximately 3 inches of water (visual inspection) (Pers comm., P. Herring).

The actual number of barges crossing over the electric barrier each year could not be determined. However, if the data collected by these two studies is representative, 3 – 5 percent of the tanks crossing the barrier could potentially transport water and entrained organisms through the electronic barrier and beyond each year. The effect of the electrified field on the contents of the barge ballast tanks is unknown.

5 RECOMMENDATIONS

Information collected during this study is important to understand water volumes and water quality conditions in barge and towboat ballast tanks and voids and is useful as a baseline for the development of additional studies to test whether barge ballast tanks are a viable vector for Asian carp transport. Although the existing literature is sparse on the tolerances of Asian carp, information on other species of carp suggests these species would be able to tolerate a wide range of water quality conditions, including high water temperature and low DO concentrations. It must be noted that the current study only provides a "snapshot" of what ballast water conditions are during a summer event and that no barge history was recorded for those tanks that contained substantial amounts of water. It is possible that those barges had leaks and had remained rafted in place rather than being kept in use. Additional sampling events and barge information during other time periods may be warranted to look at possible seasonal variability within barge and towboat ballast tanks and voids.

Larval fish survivability within a barge or towboat ballast tank has never been studied. In determining whether ballast tanks are to be considered a possible vector for larval transport, the next step should be to determine whether early developmental stages of Asian carp (eggs and larvae) are able to tolerate/survive in these tanks. In addition, other studies should be performed to help evaluate transport mechanisms for Asian carp. These should include sampling barge tanks for different life stages of Asian carp, evaluating the effects that tank leakage has on the potential transport of Asian carp, and investigating the effect of deliberate ballasting via pumps on early life stages.

6 REFERENCES

Bettoli, P. W., W. H. Neill and S. W. Kelsch. 1985. Temperature preference and heat resistance of grass carp, *Ctenopharyngodon idella* (Valenciennes), bighead carp, *Hypophthalmichthys nobilis* (Gray), and their FI hybrid. Journal of Fish Biology 27:239-247.

Chilton III, E. W. and M. I. Muoneke. 1992. Biology and management of grass carp (*Ctenopharyngodon idella*, Cyprinidae) for vegetation control: a North American perspective. Review Fish Biology and Fisheries 2:283-320.

Chunsheng, Z., L. Zhixin, and H. Henian. 1980. Ecological features of the spawning of certain fishes in the Hanjiang River after the construction of dams. Acta Hydrobio. Sin. 7(2):188-193.

Cudmore, B. and N.E. Mandrak. 2004. Biological Synopsis of Grass Carp (*Ctenopharyngodon idella*). Canadian Manuscript Report of Fisheries and Aquatic Sciences 2705. Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington ON L7R 4A6, Canada.

FAO. 1980. Freshwater Aquaculture Development in China. FAO Fisheries Technical Paper 215.

Federenko, A. Y. and F. J. Fraser. 1978. Review of grass carp biology. Interagency Committee on Transplants and Introductions of Fish and Aquatic Invertebrates in British Columbia. British Columbia, Department of Fisheries and Environment, Fisheries and Marine Service, Technical Report No. 786. 15 pp.

Golovanov, V. K. and A. K. Smirnov. 2007. Influence of the water heating rate upon thermal tolerance in common carp (*Cyprinus carpio L.*) during different seasons. Journal of Ichthyology Volume 47 (7): 538 - 543.

IDNR (Illinois Department of Natural Resources), (2009, December 6). Asian Carp Response Workgroup wraps up main operation on Chicago Sanitary Ship Canal. IDNR News Release.

Kolar, C. S., D. C. Chapman, W. R. Courtenay, C. M. Housel, J. D. Williams, and D. P. Jennings. 2007. Bigheaded carps: a biological synopsis and environmental risk assessment. American Fisheries Society, Special Publication 33, Bethesda, MD.

Leventer, H. 1979. Biological control of reservoir fish. Mekoroth Water Co., Jordan District Central Lab. Nazareth, Israel.

Negonovskaya, I. T. 1980. On the results and prospects of the introduction of phytophagous fishes into waters of the USSR. Journal of Ichthyology 20(4):101-111.

Opuszynski, K., A. Liriski, L. Myszkowski, and J. Wolnicki. 1989. Upper lethal and rearing temperatures for juvenile common carp, *Cyprinus carpio L.*, and silver carp, *Hypophthalmichthys molitrix* (Valenciennes). Aquaculture Research Volume 20 (3): 287 - 294.

Shireman, J. V. and C. R. Smith. 1983. Synopsis of biological data on the grass carp, *Ctenopharyngodon*

idella (Cuvier and Valenciennes, 1844). Food and Aquaculture Organization Synopsis. 135: 86 pp.

Tripathi, S.D. 1989. *Hypophthalmichthys molitrix* (Val.) and *Ctenopharyngodon idella* (Val.) – Exotic elements in freshwater carp polyculture in India. Pages 27-33, *In*: J. M. Mohan, editor. Exotic aquatic species in India. Special Publication 1, Asian Fisheries Society, Indian Branch.

USACE (United States Army Corps of Engineers), (2009, November 20). New eDNA Monitoring Results Spurs Rapid Response Action. USACE News Release.

Versar, Inc. 1999. Risk assessment of the potential effects of stocking triploid-certified grass carp in the Potomac River watershed on submersed aquatic vegetation. Report prepared for U.S. Environmental Protection Agency, Chesapeake Bay Program. Columbia, Maryland.

Wrigley, T.J., Toerien, D.F., Gaigher, I. G., 1988. Fish production in small oxidation ponds. Water Res. 22 (10), 1279–1285.

APPENDIX A. SURVEY DATA

Table A-1 presents the data collected during the August 2010 survey of towboat and barge tanks and voids.

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/16/10	13:16	Lemont, IL	IMT	RMT 324	H	Bow	--	S	N				docked, empty
8/16/10	13:16	Lemont, IL	IMT	RMT 324	H	S2	--	S	N				docked, empty
8/16/10	13:16	Lemont, IL	IMT	RMT 324	H	S3	--	S	N				docked, empty
8/16/10	13:34	Lemont, IL	IMT	RMT 324	H	S4	--	S	N				docked, empty
8/16/10	13:36	Lemont, IL	IMT	BOI 1006B	H	Bow	6	S	N				docked, covered
8/16/10	13:43	Lemont, IL	IMT	MBL 957	H	Bow/Stern	6	S	N				docked, empty
8/16/10	13:48	Lemont, IL	IMT	PML 1303B	H	Bow/Stern	6	S	N				docked, empty
8/16/10	13:16	Lemont, IL	IMT	RMT 324	H	Stern	6	S	Y	2.00	82.5	3.37	docked, empty
8/16/10	13:16	Lemont, IL	IMT	RMT 324	H	S1	--	S	Y	4.50	79.0	5.01	docked, empty
8/16/10	14:14	Heritage Storage Yard	IMT	KIRBY 28709	Tank	All	12	S	N				
8/16/10	14:27	Heritage Storage Yard	IMT	KIRBY 15011	Tank	All	12	S	N				
8/16/10	14:33	Heritage Storage Yard	IMT	IB 1016	Tank	All	14	S	N				
8/16/10	14:38	Heritage Storage Yard	IMT	CBC 45	Tank	All	12	S	N				
8/16/10	14:42	Heritage Storage Yard	IMT	CBC 109	Tank	All	12	S	N				
8/16/10	14:45	Heritage Storage Yard	IMT	CBC 140	Tank	All	12	S	N				
8/16/10	14:52	Heritage Storage Yard	IMT	CBC 148	Tank	All	12	S	N				
8/16/10	14:58	Heritage Storage Yard	IMT	CBC 135	Tank	All	12	S	N				
8/16/10	15:04	Heritage Storage Yard	IMT	CBC 146	Tank	All	12	S	N				
8/16/10	15:12	Heritage Storage Yard	IMT	CBC 150	Tank	All	12	S	N				
8/17/10	8:47	Power Plant - Romeoville	ARTCO	MG 698	H	S	--	S	N				docked, empty
8/17/10	8:50	Power Plant - Romeoville	ARTCO	MWG 202	H	S	6	S	N				docked, empty
8/17/10	9:00	Power Plant - Romeoville	ARTCO	MG 685	H	All	6	S	N				docked, empty
8/17/10	9:18	Power Plant - Romeoville	ARTCO	AT 664B	H	S	6	S	N				docked, loaded
8/17/10	9:21	Power Plant - Romeoville	ARTCO	CBL 314	H	S	6	S	N				docked, empty
8/17/10	9:32	Power Plant - Romeoville	ARTCO	MWG 205	H	S	6	S	N				docked, loaded
8/17/10	9:34	Power Plant - Romeoville	ARTCO	AT 310	H	S	6	S	N				docked, loaded
8/17/10	10:06	Power Plant - Romeoville	ARTCO	MWG 206	H	S	6	S	N				docked, empty

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/17/10	10:43	ARTCO Shipyard - Lemont	ARTCO	CGB 416	H	S	6	S	N				docked, empty
8/17/10	14:17	IMT - Channahon	IMT	IMT 207B	H	S	6	S	N				docked, loaded
8/17/10	14:20	IMT - Channahon	IMT	IMT 141	H	S	6	S	N				docked, loaded
8/17/10	14:23	IMT - Channahon	IMT	IMT 115	H	S	6	S	N				docked, loaded
8/17/10	14:43	IMT - Channahon	IMT	RMT 305	H	S	6	S	N				docked, loaded
8/17/10	14:46	IMT - Channahon	IMT	MST 648B	H	S	6	S	N				docked, loaded
8/17/10	14:53	IMT - Channahon	IMT	ABC 778	H	S	6	S	N				docked, loaded
8/17/10	14:57	IMT - Channahon	IMT	RMT 325	H	S	6	S	N				docked, loaded
8/17/10	15:05	IMT - Channahon	IMT	MST 706B	H	S	6	S	N				docked, loaded
8/17/10	15:20	IMT - Channahon	IMT	MST 642B	H	S	6	S	N				docked, loaded
8/17/10	8:22	Power Plant - Romeoville	ARTCO	MG 692	H	S1	6	S	Y	2.50	77.7	2.90	docked, empty
8/17/10	8:22	Power Plant - Romeoville	ARTCO	MG 692	H	S3	--	S	Y	7.00	77.7	3.28	docked, empty
8/17/10	8:22	Power Plant - Romeoville	ARTCO	MG 692	H	Stern	--	S	Y	3.00	77.8	3.55	docked, empty
8/17/10	8:34	Power Plant - Romeoville	ARTCO	MG686	H	S4	6	S	Y	10.00	80.1	2.31	docked, empty
8/17/10	8:34	Power Plant - Romeoville	ARTCO	MG686	H	S1	--	S	Y	8.00	80.0	4.40	docked, empty
8/17/10	8:34	Power Plant - Romeoville	ARTCO	MG686	H	Bow	--	S	Y	4.00	78.3	5.09	docked, empty
8/17/10	8:53	Power Plant - Romeoville	ARTCO	MG 681	H	Bow	6	S	Y	6.00	76.8	3.94	docked, empty
8/17/10	9:12	Power Plant - Romeoville	ARTCO	SER 232	H	S1	6	S	Y	5.00	83.8	3.05	docked, loaded
8/17/10	9:26	Power Plant - Romeoville	ARTCO	MG 688	H	Stern	6	S	Y	42.00	78.9	4.28	docked, loaded
8/17/10	9:42	Power Plant - Romeoville	ARTCO	MG 699	H	S	6	S	Y	13.00	81.1	2.55	docked, empty
8/17/10	9:42	Power Plant - Romeoville	ARTCO	MG 699	H	S	--	S	Y	7.00	79.8	3.62	docked, empty
8/17/10	9:42	Power Plant - Romeoville	ARTCO	MG 699	H	S	--	S	Y	8.00	80.0	4.20	docked, empty

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/17/10	9:54	Power Plant - Romeoville	ARTCO	MG 697	H	Stern	6	S	Y	7.00	80.1	4.24	docked, empty
8/17/10	9:54	Power Plant - Romeoville	ARTCO	MG 697	H	S2	--	S	Y	10.00	81.2	0.44	docked, empty
8/17/10	9:54	Power Plant - Romeoville	ARTCO	MG 697	H	S1	--	S	Y	10.00	82.0	1.10	docked, empty
8/17/10	9:54	Power Plant - Romeoville	ARTCO	MG 697	H	Bow	--	S	Y	10.00	80.8	3.45	docked, empty
8/17/10	10:55	ARTCO Shipyard - Lemont	ARTCO	SER 234	H	S2	6	S	Y	3.00	78.9	4.53	docked, empty
8/17/10	10:55	ARTCO Shipyard - Lemont	ARTCO	SER 234	H	Stern	--	S	Y	15.00	78.6	4.62	docked, empty
8/17/10	15:00	IMT - Channahon	IMT	RCI 257B	H	Stern	6	S	Y	117.00	85.7	1.85	ambient DO = 2.76 mg/L temp = 86.3
8/17/10	15:07	IMT - Channahon	IMT	IMT 113	H	S3	6	S	Y	5.00	86.3	2.42	docked, loaded
8/17/10	15:11	IMT - Channahon	IMT	RMT 326	H	S1	6	S	Y	7.00	86.7	1.86	docked, loaded
8/17/10	14:50	IMT - Channahon	IMT	CBC 205	Tank	All	12	S	N				docked, loaded
8/17/10	15:48	IMT - Channahon	IMT	Mary C	Towboat	Bow	1	S	N				
8/18/10	9:28	Romeoville	Hanson Marine	MSC 9801	Deck	All	6	S	N				
8/18/10	9:35	Romeoville	Hanson Marine	MSC 8100	Deck	All	6	S	N				
8/18/10	9:44	Romeoville	Hanson Marine	MSC 0005	Deck	All	6	S	N				
8/18/10	9:51	Romeoville	Hanson Marine	MSC 0101	Deck	All	6	S	N				
8/18/10	9:56	Romeoville	Hanson Marine	MSC 9302	Deck	All	6	S	N				
8/18/10	10:05	Romeoville	Hanson Marine	MSC 0004	Deck	All	6	S	N				
8/18/10	10:11	Romeoville	Hanson Marine	MSC 8900	Deck	All	6	S	N				
8/18/10	10:14	Romeoville	Hanson Marine	MSC 1107	Deck	All	6	S	N				
8/18/10	10:18	Romeoville	Hanson Marine	MSC 1109	Deck	All	6	S	N				

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/18/10	10:38	Romeoville	Hanson Marine	MSC 9600	Deck	All	6	S	N				
8/18/10	10:42	Romeoville	Hanson Marine	MSC 9601	Deck	All	6	S	N				
8/18/10	10:46	Romeoville	Hanson Marine	MSC 9800	Deck	All	6	S	N				
8/18/10	10:49	Romeoville	Hanson Marine	MSC 0003	Deck	All	6	S	N				
8/18/10	10:52	Romeoville	Hanson Marine	MSC 9300	Deck	All	6	S	N				
8/18/10	10:25	Romeoville	Hanson Marine	MSC 1106	Deck	P2	6	S	Y	6.00	82.8	5.44	
8/18/10	10:27	Romeoville	Hanson Marine	MSC 1106	Deck	P1	6	S	Y	9.00	83.4	5.32	
8/18/10	11:26	Romeoville	Hanson Marine	Morris	Towboat	Bow	1	S	N				
8/18/10	9:02	Romeoville	Hanson Marine	Stacey Dianne	Towboat	Bow	1	S	Y	18.00	84.5	5.10	
8/19/10	8:28	south Chicago	Kindra Lake Towing	TMS 200	Deck	All	14	S	N				
8/19/10	8:48	south Chicago	Kindra Lake Towing	CBC 4507	Deck	P4	6	S	Y	10.00	69.7	5.08	
8/19/10	8:53	south Chicago	Kindra Lake Towing	CBC 4507	Deck	P3	--	S	Y	24.00	69.8	5.34	
8/19/10	8:58	south Chicago	Kindra Lake Towing	CBC 4507	Deck	P2	--	S	Y	11.00	69.5	5.57	
8/19/10	9:03	south Chicago	Kindra Lake Towing	CBC 4507	Deck	P1	--	S	Y	7.00	69.7	5.79	
8/19/10	9:08	south Chicago	Kindra Lake Towing	CBC 4507	Deck	Bow1	--	S	Y	5.00	69.6	5.44	
8/19/10	9:15	south Chicago	Kindra Lake Towing	CBC 4507	Deck	Bow2	--	S	Y	5.00	69.5	5.33	
8/19/10	9:48	south Chicago	Kindra Lake Towing	CBC 1253	Deck	P1	18	S	Y	6.50	69.6	3.74	
8/19/10	9:50	south Chicago	Kindra Lake Towing	CBC 1253	Deck	P4	18	S	Y	5.00	69.7	3.60	

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/19/10	9:55	south Chicago	Kindra Lake Towing	CB 276	Deck	S6	14	S	Y	5.00	70.0	5.05	
8/19/10	10:00	south Chicago	Kindra Lake Towing	CB 276	Deck	S5	--	S	Y	6.00	69.7	5.72	
8/19/10	10:05	south Chicago	Kindra Lake Towing	CB 276	Deck	S4	--	S	Y	4.50	69.9	6.17	
8/19/10	10:10	south Chicago	Kindra Lake Towing	CB 276	Deck	S3	--	S	Y	5.00	69.9	5.82	
8/19/10	10:15	south Chicago	Kindra Lake Towing	CB 276	Deck	Bow	--	S	Y	18.00	69.5	5.93	
8/19/10	8:16	south Chicago	Kindra Lake Towing	OR 5367	H	P	6	S	N				
8/19/10	9:32	south Chicago	Kindra Lake Towing	MST 748B	H	S	6	S	N				
8/19/10	9:35	south Chicago	Kindra Lake Towing	MST 739B	H	S	6	S	N				
8/19/10	9:43	south Chicago	Kindra Lake Towing	ING 2175	H	S	6	S	N				
8/19/10	10:50	Walsh Slip	Kindra Lake Towing	IMT 140	H	S	6	S	N				
8/19/10	10:52	Walsh Slip	Kindra Lake Towing	T 13969	H	S	6	S	N				
8/19/10	10:55	Walsh Slip	Kindra Lake Towing	ING 4766	H	S	6	S	N				
8/19/10	8:10	south Chicago	Kindra Lake Towing	OR 4901	H	P2	6	S	Y	16.00	70.4	3.23	
8/19/10	8:38	south Chicago	Kindra Lake Towing	BUCKLEY	Towboat	Bow	1	S	N				
8/19/10	8:32	south Chicago	Kindra Lake Towing	MORGAN	Towboat	Bow	1	S	Y	56.00	72.1	3.18	
8/19/10	8:40	south Chicago	Kindra Lake Towing	OLD MISSION	Towboat	Stern	1	S	Y	72.00	69.2	2.54	Ambient: 70.0 deg F; 8.46 mg/L DO
8/20/10	8:40	Lemont	American Commercial Lines	TTBL 4104B	H	All	6	S	N				

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/20/10	8:54	Lemont	American Commercial Lines	ACL 00549	H	All	6	S	N				
8/20/10	8:56	Lemont	American Commercial Lines	ACBL 1431	H	All	6	S	N				
8/20/10	9:03	Lemont	American Commercial Lines	WWT 846	H		6	S	N				
8/20/10	8:15	Lemont	American Commercial Lines	LF 13413	H	S	6	S	Y	5.00	78.1	4.78	
8/20/10	8:33	Lemont	American Commercial Lines	ACL 00233	H	P1	6	S	Y	3.00	77.9	6.77	
8/20/10	8:45	Lemont	American Commercial Lines	PV 507	H	S3	6	S	Y	3.00	79.4	7.80	
8/20/10	9:22	Lemont	American Commercial Lines	ACL 00549	H	P4	6	S	Y	10.00	79.0	5,72	Being cleaned/tanks being pumped out
8/20/10	10:21	Lemont	ARTCO	ACL 00549	H	P2	--	S	Y	5.00	79.0	4.53	
8/20/10	10:22	Lemont	ARTCO	ACL 00549	H	Bow	--	S	Y	76.00	80.0	5.86	
8/20/10	8:20	Lemont	American Commercial Lines	Chem 239	Tank	All	12	S	N				
8/20/10	8:23	Lemont	American Commercial Lines	Chem 229	Tank	All	12	S	N				
8/20/10	8:28	Lemont	American Commercial Lines	Hines 412	Tank	All	12	S	N				
8/20/10	8:07	Lemont	American Commercial Lines	T.E. Ragsdale	Towboat	Bow	1	S	N				NO BALLAST TANKS

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/20/10	9:00	Lemont	American Commercial Lines	Jack Crowley	Towboat	Bow	1	S	N				NO BALLAST TANKS
8/20/10	9:46	Lemont	American Commercial Lines	Steve McKinny	Towboat	Bow	1	S	N				NO BALLAST TANKS
8/20/10	10:17	Lemont	ARTCO	Buster White	Towboat	Bow	1	S	N				
8/20/10	10:20	Lemont	ARTCO	Harvest Run	Towboat	Bow	1	S	Y	56.00	79.0	3.77	
8/23/10	9:01	Ottawa	ARTCO	AT 315	H	All	6	S	N				
8/23/10	9:06	Ottawa	ARTCO	AB 133	H	All	6	S	N				
8/23/10	9:09	Ottawa	ARTCO	AT 346B	H	All	6	S	N				
8/23/10	9:12	Ottawa	ARTCO	AT 732B	H	All	6	S	N				
8/23/10	9:15	Ottawa	ARTCO	AT 608B	H	All	6	S	N				
8/23/10	9:15	Ottawa	ARTCO	SER 230	H	All	6	S	N				
8/23/10	9:18	Ottawa	ARTCO	AT 636B	H	All	6	S	N				
8/23/10	9:24	Ottawa	ARTCO	ART 35263B	H	All	6	S	N				
8/23/10	9:27	Ottawa	ARTCO	CBL 315	H	All	6	S	N				
8/23/10	9:30	Ottawa	ARTCO	TCB 444	H	All	6	S	N				
8/23/10	9:30	Ottawa	ARTCO	XL 656	H	All	6	S	N				
8/23/10	9:39	Ottawa	ARTCO	AT 749B	H	All	6	S	N				
8/23/10	9:39	Ottawa	ARTCO	ART 603B	H	All	6	S	N				
8/23/10	9:42	Ottawa	ARTCO	ART 164	H	All	6	S	N				
8/23/10	9:42	Ottawa	ARTCO	ART 164	H	All	6	S	N				
8/23/10	9:59	Ottawa	ARTCO	SER 234	H	All	6	S	N				
8/23/10	9:59	Ottawa	ARTCO	CAB 416	H	All	6	S	N				
8/23/10	11:37	Seneca	ARTCO	ATI 680B	H	All	6	S	N				
8/23/10	11:37	Seneca	ARTCO	TCB463B	H	All	6	S	N				
8/23/10	11:40	Seneca	ARTCO	RRS 8182	H	All	6	S	N				
8/23/10	11:40	Seneca	ARTCO	AT735B	H	All	6	S	N				
8/23/10	12:27	Morris	ARTCO	AB67	H	All	6	S	N				
8/23/10	12:27	Morris	ARTCO	AB97	H	All	6	S	N				
8/23/10	8:56	Ottawa	ARTCO	AB85	H	S2	6	S	Y	3.00	80.0	5.10	
8/23/10	8:58	Ottawa	ARTCO	ART 303	H	Stern	1	S	Y	3.00	80.0	5.10	
8/23/10	10:05	Ottawa	ARTCO	Gold Star	Towboat	Bow	1	S	N				
8/23/10	10:05	Ottawa	ARTCO	Mary "G"	Towboat	Bow	1	S	N				

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/23/10	12:37	Morris	ARTCO	Bob Page	Towboat	Bow	1	S	N				
8/24/10	9:06	Lemont, power plant	ARTCO	MWG 204	H	All	6	S	N				
8/24/10	9:08	Lemont, power plant	ARTCO	MG 699	H	All	6	S	N				2nd check different location
8/24/10	9:08	Lemont, power plant	ARTCO	MG 697	H	All	6	S	N				2nd check different location
8/24/10	9:11	Lemont, power plant	ARTCO	MG 698	H	All	6	S	N				2nd check different location
8/24/10	9:14	Lemont, power plant	ARTCO	MG 680	H	All	6	S	N				
8/24/10	9:18	Lemont, power plant	ARTCO	MG 206	H	All	6	S	N				
8/24/10	9:21	Lemont, power plant	ARTCO	MG 207	H	All	6	S	N				
8/24/10	8:54	Lemont, power plant	ARTCO	MG 696	H	STERN	6	S	Y	3.00	78.7	4.78	
8/24/10	8:54	Lemont, power plant	ARTCO	MG 069	H	STERN	6	S	Y	8.00	79.0	3.53	
8/25/10	9:06	Channahon	IMT	IMT 143	H	All	6	S	N				
8/25/10	9:08	Channahon	IMT	IMT 129	H	All	6	S	N				
8/25/10	9:10	Channahon	IMT	IMT 111	H	All	6	S	N				
8/25/10	9:12	Channahon	IMT	TBL 39	H	All	6	S	N				
8/25/10	9:25	Channahon	IMT	IMT 205B	H	All	6	S	N				
8/25/10	9:25	Channahon	IMT	IMT 118	H	All	6	S	N				
8/25/10	9:27	Channahon	IMT	OR 5490	H	All	6	S	N				
8/25/10	9:27	Channahon	IMT	IMT 137	H	All	6	S	N				
8/25/10	9:34	Channahon	IMT	INO 71010	H	All	6	S	N				
8/25/10	9:38	Channahon	IMT	ING 2400	H	All	6	S	N				
8/25/10	9:52	Channahon	IMT	INO 75116	H	All	6	S	N				
8/25/10	9:55	Channahon	IMT	INO 85171	H	All	6	S	N				
8/25/10	9:55	Channahon	IMT	ING 2147	H	All	6	S	N				
8/25/10	13:16	Romeoville/Loading area	Hanson Marine	MSC 9301	H	All	6	S	N				
8/25/10	13:16	Romeoville/Loading area	Hanson Marine	MSC 9903	H	All	6	S	N				
8/25/10	13:20	Romeoville/Loading area	Hanson Marine	MSC 9001	H	All	6	S	N				
8/25/10	13:26	Romeoville/Loading area	Hanson Marine	MSC 8803	H	All	6	S	N				
8/25/10	13:26	Romeoville/Loading area	Hanson Marine	MSC 9900	H	All	6	S	N				
8/25/10	13:28	Romeoville/Loading area	Hanson Marine	MSC 9904	H	All	6	S	N				

Table A-1. August 2010 survey data.

Date	Time	Location	Vessel Company	Vessel Name & ID	Type (Hopper, Platform, Towboat)	Tank Sampled (Port, Starbrd)	Total # Tanks	Hatch Sealed (S) or Unsealed (U)	Water Present (Y or N)	Water Depth (inches)	Temp (°F)	DO (mg/L)	Comments
8/25/10	13:33	Romeoville/Loading area	Hanson Marine	MSC 8405	H	All	6	S	N				
8/25/10	13:33	Romeoville/Loading area	Hanson Marine	MSC 8700	H	All	6	S	N				
8/25/10	13:20	Romeoville/Loading area	Hanson Marine	MSC 0002	H	P3	6	S	Y	3.50	84.7	5.87	

APPENDIX B. SURVEY PHOTOS, AUGUST 2010

Figure B-1. Loaded (upper) and unloaded (lower) barges. Note minimal clearance under bridge.

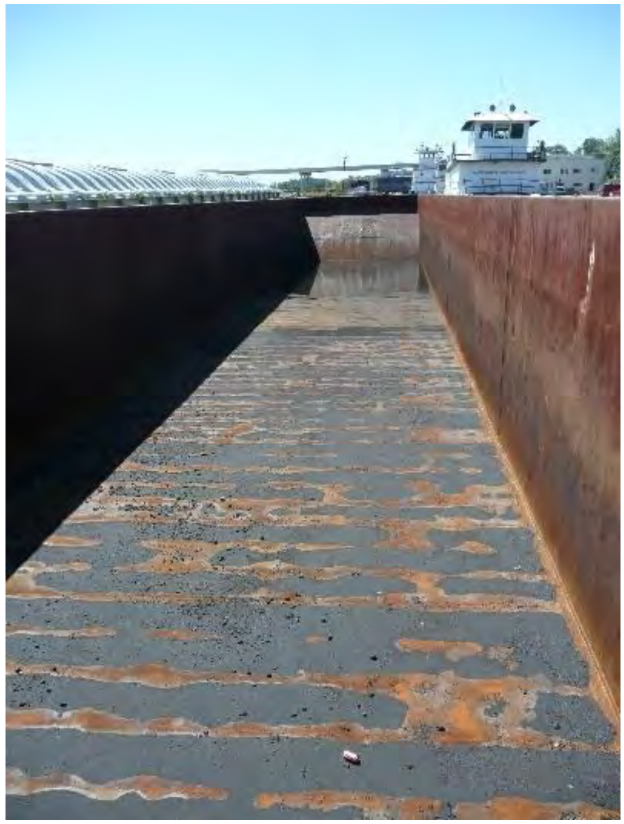

Figure B-2. Interior of empty hopper barge (upper). Loading hopper barge (lower).

Figure B-3. Raised and flush hatch covers on rafted barges (Upper). Raised access hatch (lower).

Figure B-4. Measuring temperature and dissolved oxygen on rafted barge (upper). Interior of barge void space (lower). Water depth approximately 3 inches.

APPENDIX C. TOWBOAT AND BARGE DESIGN AND OPERATION

Towboats:
Towboats have void tanks, normally located at the bow or stern of the vessel, which are used for ballasting operations. Ballast water is pumped into a void tank (not the bilge area) by an onboard pump through permanent piping. The discharge of this ballast water is done usually through an onboard pump and permanent piping. Some towboats, however, are not equipped with onboard pumps and therefore use portable pumps. Typical portable pumps are 2-inch or 3-inch trash pumps that require suction and discharge hoses.

Towboats may take on ballast water as fuel is consumed and before refueling takes place. This ballasting is necessary to keep the towboat trimmed to the operating draft required or desired for that particular vessel. The ballast water is discharged immediately before refueling or during refueling. Occasionally ballast may be taken onboard to improve handling and remain in the tanks for months before being discharged.

Barges:
There are several types of barges: dry cargo hopper barges, tank barges and deck barges.

Dry cargo hopper barges are the most common barges. They measure 200 feet long by 35 feet wide by 12 to 14 feet tall. These barges look like giant empty shoe boxes with the cargo down in the box. These barges are built such that there is one bow tank, 4 or 5 wing (or side) tanks and one stern tank. The wing tanks go from one side of the barge, under the cargo hopper, and to the other side of the barge. At the side of the cargo hopper, the wing tanks are about 3 feet wide. Under the cargo hopper, the tanks are about 18 inches deep. By design, water is free to flow from side to side because there is no centerline bulkhead (or wall) to prevent this flow of water.

Tank barges have more varied sizes. A 10,000 barrel capacity barge measures 200 feet by 35 feet by 12 feet. Larger capacity barges measure 296 feet long by 54 feet wide by 12 feet. The tank barges have cargo boxes like the dry cargo barges although they are cargo tanks. There are usually 3 cargo tanks or compartments per barge. Similar to dry cargo barges, tank barges have a bow tank, 4 or 5 wing tanks and a stern tank. Some tank barges may have a center bulkhead resulting in separate port and starboard tanks.

Deck barges are constructed to carry the cargo on the deck of the barge and not down in a cargo box. There are few standard sizes for deck barges and they come in many sizes. Deck barges usually have one, if not more, centerline bulkheads. This means that the water cannot flow from one side of the barge to the other side. Deck barges usually have more individual void tanks because of the centerline bulkhead(s). The centerline bulkhead may or may not dissect the bow and stern tanks into two or more separate tanks. Unlike dry cargo barges, deck barges do not have wing tanks but rather void tanks that are much larger than wing tanks. These void tanks can be 12 – 14 feet deep since they reach from the barge hull to the deck.

Barges do not have permanent piping to pump water into or out of their tanks; portable pumps are used. Barges may be ballasted to clear low bridges such as the low railroad bridge in Lemont. Barge tanks are inspected regularly. Operators questioned about standard ballasting practices for this study indicated that tanks are inspected once per 6-hour watch when active or once per day if rafted and inactive.

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